

**Thesis/
Reports
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**Boreal Owl Population Trend,
Habitat Use, and Dispersal:
Final Report**

COOP AGREEMENT
UNIVERSITY OF
WYOMING

FINAL REPORT FOR RESEARCH AGREEMENT

#RMRS-99600-RJVA

"Field Data Collection for the Study of the
Dispersal of Boreal Owls Among Subpopulations
in the Central and Northern Rocky Mountains"
UNIVERSITY OF WYOMING

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Boreal Owl Population Trend, Habitat Use, and Dispersal: Final Report

This research was supported in part by funds provided by the Rocky Mountain Research Station,
Forest Service, U.S. Department of Agriculture.

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December 1999

Table of Contents

What this report covers	3
Background	3
Chapter 1	
Metapopulation Structure and Dispersal.....	4
Goal of Research	4
Rationale	6
Metapopulation Theory.....	6
Methods and progress to date.....	7
Collection of Blood and Tissue Samples	7
Genetic Analysis.....	7
Matrix/Gene Flow Model	8
Results From 1999 Field Studies.....	9
Idaho Panhandle National Forest.....	9
Payette National Forest, Idaho	9
Flathead National Forest, Montana.....	10
Beaverhead National Forest, Montana.....	10
Bridger-Teton National Forest, Wyoming	10
Medicine-Bow National Forest, Wyoming.....	10
Routt National Forest, Colorado.....	11
Chapter 2	
Boreal Owl Nest Box Use in the Blowdown on Routt National Forest	12
Introduction	12
Methods	13
Results	13
Discussion.....	14
Chapter 3	
Long-term Monitoring of a Nest Box System on the Payette National Forest.....	15
Introduction	15
Methods.....	16
Nest Box Placement.....	16
Nest Box Design and Construction	17
Monitoring Nest Boxes	17
Monitoring Results.....	17
Discussion	19
Acknowledgments.....	20
Literature Cited	20

WHAT THIS REPORT COVERS

Dr. Gregory D. Hayward

After joining the University of Wyoming in 1995, I began building a research program examining the consequences of forest management on certain vertebrates in subalpine forests of the Rocky Mountains. This research is not a change in direction but an extension of the program I maintained while working for various employers during the previous decade. I now have 5 graduate students and a research associate in my lab working on projects related to my broad research goals. Our projects address a variety of spatial and temporal scales and several areas of population ecology. For instance, Ph.D. students in the lab are addressing questions that range from feeding ecology and gut physiology of northern flying squirrels to population genetics of boreal owls.

This year, funding from several sources (Rocky Mountain Forest and Range Experiment Station, Idaho Fish and Game, several National Forests, and Global Forest) supported field studies of boreal owls. Although individual grants supported fieldwork directed at particular questions, the research and management studies on boreal owls are all related. Therefore, I chose to write a single progress report integrating the work from several projects. Because none of these projects is near completion, this report is a summary and designed to describe the field work and analysis accomplished with the funding we received. More extensive analysis and products will be produced during the coming year.

BACKGROUND

My work on boreal owls currently addresses 4 major topics: (1) administrative studies monitoring population trend, (2) patterns of habitat use at a landscape scale, (3) comparative demography of boreal owls in different environments, and (4) genetic structure and movements of boreal owls in North America. All of these studies build upon my earliest studies of boreal owls in the wilderness of central Idaho (e.g. Hayward et al. 1993) and rely on the cooperative nest box monitoring program I established with numerous cooperators in the Rocky Mountains and Alaska.

From 1987-1989, I established systems of nest boxes on Payette, Idaho Panhandle, and Beaverhead National Forests. These systems have been maintained to varying degrees. We have monitored the boxes on the Payette N.F. (max. of 455 boxes) yearly since 1988. Boxes on the Idaho Panhandle have been monitored sporadically and have not been maintained during the past 5 years. Boxes on the Beaverhead N. F. were monitored for about 5 consecutive years, were ignored for a few years, and have now been monitored for 2 more years. Currently we work with

9 other National Forests and the Colorado State Forest Service on associated nest box monitoring systems.

This report will be organized with 3 chapters. The first will describe fieldwork and cooperative efforts associated with our studies of boreal owl metapopulation structure and gene flow. The second will provide results from our first year of monitoring nest box use in the blowdown on the Routt National Forest. The third will review results from our long-term monitoring program on the Payette National Forest, Idaho and will provide a brief update on our analysis of landscape scale habitat use. I will not report on progress of the studies comparing demography of boreal owls because the work doesn't involve current field studies.

Chapter 1: Metapopulation Structure and Gene Flow: Patterns in Boreal Owls

Marni E. Koopman, Dr. Gregory D. Hayward, Dr. David B. McDonald

Goal of Research

We will use molecular techniques to assess dispersal of boreal owls (*Aegolius funereus*) and identify the metapopulation structure of the species in North America. We will evaluate gene flow between disjunct populations of boreal owls in the Rocky Mountains and more contiguous populations of Alaska and Canada (Figure 1). Because boreal owls in the western U. S. are found only in high elevation coniferous forest, their distribution suggests a natural metapopulation structure (Hayward et al. 1993). We have hypothesized that small subpopulations are separated by large areas of unsuitable habitat, with dispersal acting to connect these subpopulations.

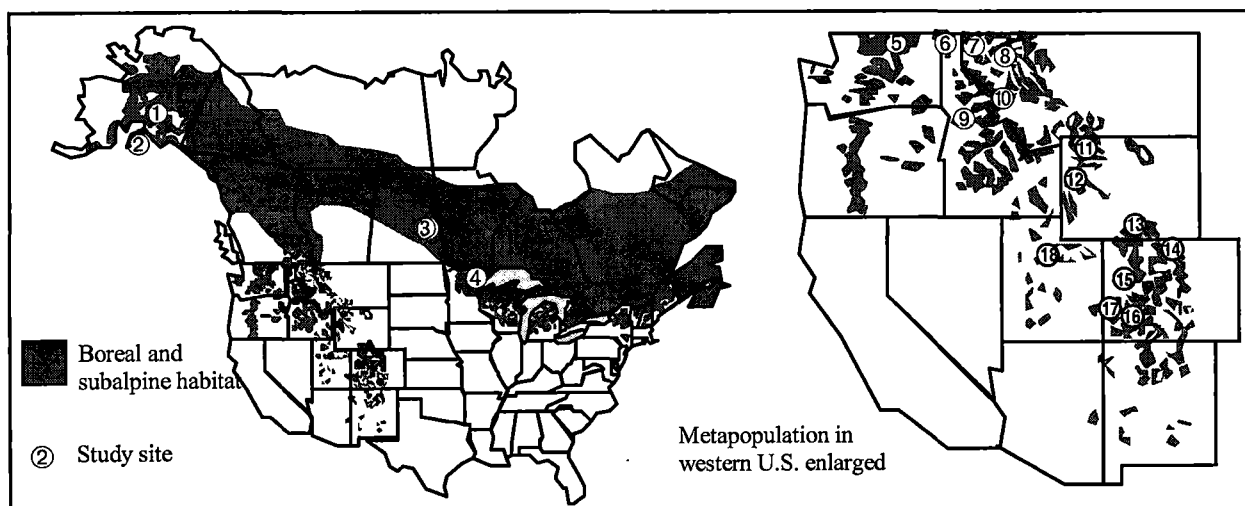


Figure 1. Metapopulation structure of boreal owl populations in North America. Subpopulations throughout the western U.S. exhibit patchy distribution whereas those in Canada and Alaska are largely continuous. Genetic distance is expected to reflect connectivity among populations.

Within the context of metapopulation structure, boreal owls exhibit a spectrum of connectivity. The highly linked populations of northern Canada constitute a mainland population, but we predict that the Rocky Mountain populations are so distant from this mainland that genetic differentiation has occurred. However, subpopulations of southwestern Canada probably interact with the larger continuous northern populations in an island-mainland relationship. By analyzing DNA samples we can assess and compare dispersal and gene flow among populations which differ in geographic isolation (Waser and Strobeck 1997, Davies et al. 1999) and examine the results in light of metapopulation theory.

Our main objective is to investigate the impact of matrix (non-habitat patches) type on gene flow rates among boreal owl populations in a variety of geographic configurations in North America. We expect to find that some populations are more isolated than others, with lower rates of gene flow. We can determine which features may act as barriers to dispersal by comparing habitat types surrounding populations with high and low rates of gene flow, thus integrating both landscape ecology and metapopulation theory. This information can then be applied to resource management, thus providing necessary data for the design of forest harvest strategies that decrease the likelihood of extinction of subpopulations by retaining habitat configurations necessary for dispersal.

Investigation of dispersal rates and barriers to dispersal is an important step to understanding the response of boreal owls to habitat patchiness. Research on metapopulation dynamics highlights the interdependency of seemingly independent subpopulations, and the negative consequences of isolating such subpopulations. Our research will contribute not only critical empirical data to the general development of metapopulation theory; it will also assess the influence of matrix configuration (often ignored in metapopulation analysis) on metapopulation dynamics. Thus, this research will link metapopulation theory with landscape ecology. The primary questions we wish to address include:

- ◆ How are populations of boreal owls genetically structured? We hypothesize that patchy southern populations will be more differentiated than continuous Alaskan and Canadian populations.
- ◆ To what extent does incorporating matrix composition improve a metapopulation model based on distance? Distance may be the most important factor, but we hypothesize that matrix composition will play an important role in regulating genetic exchange among populations.
- ◆ What types of matrix features (e.g. distance, elevation, habitat type) cause isolation of boreal owl populations? How do geographic features interact to influence successful dispersal

between populations? We hypothesize that forested habitats will provide more connectivity than non-forested habitats, and that heavily developed matrices will provide the least connectivity.

- ◆ Is gene flow among disjunct populations sufficient to ensure long-term persistence of individual subpopulations? How much connectivity is sufficient to maintain genetic diversity within populations that differ in size or distance from adjacent populations? We expect that the most isolated populations of boreal owls are at risk of extinction due to genetic isolation. However, boreal owls may have such advanced dispersal mechanisms that even extremely isolated populations are genetically diverse.

Rationale

Timber harvest in the western U.S. has recently expanded to include more subalpine spruce-fir in order to reduce pressure on lower elevation pine stands. Therefore, species associated with spruce-fir are experiencing increasing levels of habitat alteration. Because boreal owls are classified as a sensitive species in most western National Forests, a management plan for this species is necessary. Current trends in species management emphasize waiting until persistence of a species is in peril prior to proposing sound management strategy. This emergency room approach to conservation leads to high cost and low success. Especially for obligates of mature forests, restoration of habitat and enhancement of population processes can take many generations, thus reducing the likelihood of success if these processes have been seriously degraded.

Investigation of dispersal rates and barriers to dispersal is an important step to understanding the response of boreal owls to forest management. Recent research on metapopulation dynamics highlights the interdependency of seemingly independent subpopulations, and the negative consequences of isolating such subpopulations. Our research will not only contribute essential information to the development of a conservation strategy for boreal owls in North America; it will also provide critical empirical data to the general development of metapopulation theory.

Metapopulation Theory

In addition to providing knowledge necessary for management of boreal owls, our study will provide insight to metapopulation theory. Understanding of metapopulation dynamics suffers from a lack of empirical evidence regarding the structure and function of medium and large vertebrate populations that occur as natural metapopulations (Stacey et al. 1997). As populations of many species become fragmented due to human influences, interest in the problems associated with fragmentation has escalated. However, most studies involve species whose habitat has become disjunct rather than a naturally occurring metapopulation. These

species may not have highly developed dispersal mechanisms. Boreal owls in the western U.S. have persisted in a highly fragmented system over numerous generations. Dispersal is vital to their ability to persist in such a system, and therefore this mechanism is well developed and highly effective. The natural distribution of boreal owls in North America provides an opportunity to study dispersal dynamics and genetic diversity of a species that likely exhibits a variety of population structures: high connectivity in the north, island-mainland structure in southern Canada, and classic metapopulation in the western U.S. We predict that this species will also exhibit a range of genetic diversity reflecting the importance of long-distance dispersal to local population dynamics.

Methods and progress to date

Collection of blood and tissue samples

Collection of blood samples for DNA analysis has been facilitated by the long-term boreal owl research program established by Dr. Gregory Hayward in cooperation with a network of collaborators. We collect blood samples annually throughout much of the Rocky Mountains. In addition to samples obtained from our monitoring efforts, we obtained (or have agreements to obtain) blood and tissue samples from cooperators in Canada, Alaska, Minnesota, and Colorado. These include 16 samples from boreal owls in Alaska; 200+ samples from Canada, 200+ samples from Minnesota, and 24 samples from the San Juan mountains of southern Colorado.

Field work in the Rocky Mountains began in 1998 and will continue each spring and summer through 2001. During nesting, which lasts May - July, blood samples are collected from adults and nestlings throughout the U.S. and Canada for genetic analyses. Adult females and nestlings are captured in the nest box, while adult males are trapped as they return to feed the young. Nestlings and adults are banded and a blood sample is collected. Revisitation to nest boxes shows that boreal owl nestlings as young as 1 day old have been bled successfully with no apparent detrimental effects.

Currently we have over 400 blood or tissue samples from boreal owls throughout North America. During the first 2 field seasons we were able to check over 2,000 nest boxes in Montana, Wyoming, Idaho, and Washington. Nest boxes in Colorado and Alaska were checked by cooperating biologists and the samples sent to us. Boreal owl populations will continue to be monitored for 1-2 more field seasons.

Genetic analysis

Our sampling design encompasses the entire distribution of boreal owls in North America, and specifically addresses the issue of both matrix composition and extent. Documenting long-distance dispersal by telemetry or other methods is both rare and difficult in practice (Koenig et al. 1996). Microsatellite DNA data provide novel and efficient ways of assessing dispersal rates and connectivity (Waser and Strobeck 1997, Davies et al. 1999). Given feasible sample sizes per population, and expected levels of allelic diversity among populations, dispersing individuals can be identified and assigned, often with high probability, to their population of origin.

Due to their high variability, relative ease of scoring, and selective neutrality, microsatellites are considered to be one of the most powerful molecular markers available today (Goldstein and Pollock 1997, Jarne and Lagoda 1996). These loci are simple, tandemly repeated sequences of DNA that evolve through the gain or loss of repeat units, most often via slippage replication errors (Tautz 1989, Schl tterer and Tautz 1992). Mutation rates may be as high as 1×10^{-3} per generation. Microsatellites may reveal differentiation among small, isolated populations that cannot be distinguished by analysis of other, more slowly evolving loci (Bruford and Wayne 1993, Jarne and Lagoda 1996, McDonald and Potts 1997).

Blood samples are stored and processed in the microsatellite DNA laboratory of D. McDonald at the University of Wyoming. DNA is extracted and amplified by polymerase chain reaction (PCR) using an MJR PTC-200 Peltier thermal cycler. Microsatellite DNA will be run, and alleles identified, on a LiCor automated sequencer. DNA extraction from samples collected during the previous 2 summers has been completed.

We are currently assessing cross-specific avian primers for amplification of variable loci. The microsatellite laboratory at University of Wyoming has a battery of avian primers available. Four primers have been tested on boreal owl DNA; three amplified and one was polymorphic. We are collaborating with other researchers studying boreal owls, burrowing owls, and spotted owls in order to identify and optimize appropriate primers.

Matrix/gene flow model

A model of boreal owl distribution and movement in North America will be created using calculations of gene flow between individual populations. We will begin with a simple model that includes gene flow and geographic distance. We will calculate habitat patch size and distance between patches from GIS base maps. Geographic information system (GIS) base maps

will be drawn largely from GAP analysis data (Scott et al. 1991) completed for all western states north of New Mexico. GAP data provide information on the range of subalpine habitat, which, for the model, we will assume to be the range of boreal owls. We will also quantify matrix composition and extent. These variables will be included in a deterministic model of boreal owl gene flow.

We will add individual components of matrix composition to the distance model and assess goodness of fit. If most variance in gene flow is explained simply by the distance variable, we can conclude that matrix type plays a small role in dispersal. However, if geographic distance among some populations is relatively small yet genetic distance is great, intermediate geographic features likely play a greater role. We will test the robustness of the model by making predictions about sampled populations and comparing predicted rates of gene flow with measured rates of gene flow.

The integration of a metapopulation model and a model of geographic features will ultimately facilitate inferences regarding the influence of management in the matrix on metapopulation dynamics. The resulting functional relationship between habitat and gene flow could be applied to the entire range of boreal owls in North America to produce a predictive map of gene flow. Furthermore, the model could help identify critical subpopulations that link portions of the metapopulation or provide a source for dispersers to multiple subpopulations. Such valuable information will be released to scientists and forest managers through publication of manuscripts and cooperative formulation of a conservation strategy for boreal owls in the U.S.

Results from 1999 Field Studies

We monitored nest boxes on 8 National Forests during the summer of 1999. Results from each forest are summarized below. Data from Caribou National Forest is not included. No nesting owls were located on this forest.

Idaho Panhandle National Forest

Bonner's Ferry.--Due to extreme snow conditions, only 33 boxes on Bonner's Ferry District could be accessed in 1999. Of these boxes, 25 were in usable condition (Table 1). These boxes had not been maintained regularly, so many were filled with lichen nests from squirrels. Only 2 boxes showed evidence of having been used by boreal owls, and both contained old nests rather than active nests.

Priest Lake.--In 1999, nest boxes on the Priest Lake District were monitored by Forest Service biologists. No nesting boreal owls were found. For further information, contact Tim Laysen, Priest Lake Ranger District, Idaho Panhandle National Forest.

Payette National Forest, Idaho

River of No Return Wilderness.--The River of No Return Wilderness was not monitored in 1999 due to shortages in funding and volunteers.

Long-term Monitoring System.--Details of the results from nest-box monitoring on the managed portion of the Payette National Forest are presented in a later section of this report (see Nest Box Monitoring: Payette National Forest). In 1999, we obtained blood from 17 boreal owls captured from 6 nests on the Payette N. F. (Tables 1 and 2).

Flathead National Forest, Montana

Two-hundred boxes were hung on the Flathead National Forest in the 1980's. However, the boxes were only monitored for a few years. They have not been checked or maintained for about 10 years. Many boxes have been lost due to logging pressure. Many others were burned during an extensive forest fire. Those that were found were often in unusable condition because they had been chewed by squirrels. Additionally, many boxes were constructed of plywood, which appears to attract squirrels and does not withstand weathering. Thus, of 65 boxes that were monitored in 1999, only 21 were present and in usable condition (Table 1).

Beaverhead National Forest, Montana

There are 194 nest boxes on the Beaverhead National Forest. These boxes were established in 1989 by Patricia Heekin working for G. Hayward and J. Jones. They were monitored for the first few years after being established but, due to funding constraints and changes in Forest personnel, have not been maintained or monitored on a regular basis. We monitored and maintained all 194 boxes in 1998 and 1999. In 1999, we caught and banded 17 individual boreal owls from 4 nests (Tables 1 and 2).

In 1999, boreal owls in Idaho and Montana appeared to be nesting lower in elevation than usual, and fewer nests were found. Two recaptures were recorded on the Beaverhead. An adult female on eggs had been banded in 1998 as a nestling less than one mile from her subsequent nest. Also, a male found roosting in a box in 1998 was captured in 1999 as he fed his young in a box within a mile from his initial capture location. Unlike 1998, no second nests were found.

Bridger-Teton National Forest

One hundred boxes were hung in the Bridger-Teton National Forest throughout the Gray's River watershed in summer, 1998. These boxes were monitored for use in June-July 1999. While grass nests were common, no boreal owl activity was found (Table 1).

Medicine-Bow National Forest, Wyoming

One-hundred and fifty boxes were monitored on the Medicine Bow National Forest. One active boreal owl nest was located. However, this nest failed and only the adult female was bled and banded (Table 2). Additional data on nest box use and condition are available through the Laramie office of the U.S.F.S.

Routt National Forest, Colorado

Nest boxes were hung on the Routt National Forest in 1998 in order to assess use of the blowdown for nesting by boreal owls and other forest birds and mammals. Evidence of boreal owl interest in nest boxes was observed by feathers on the entrance hole of many boxes. However, no active nests were found. Preliminary results (Chapter 2) have been submitted to the Routt National Forest, and a final report will be submitted in 2000.

Table 1. Nest box use on 6 National Forests in Colorado, Wyoming, Montana, and Idaho. Boxes were monitored during May-June 1999.

Forest	Payette N.F.	Beaverhead N.F.	Bridger-Teton N.F.	Idaho Panhandle N.F.	Flathead N.F.	Routt N.F.
Boxes attempted	438	191	100	33	62	289
Boxes gone or not found	45	4	0	6	35	0
Usable boxes	344	179	100	25	21	289
Lichen	55	32	6	11	7	2
Grass	32	84	30	4	0	23
Boreal owl nests	6	4	0	0	0	0
Saw whet owl nests	4	2	0	0	0	0
Flying squirrel nests	6	2	5	1	1	0
Pine squirrel nests	0	0	0	0	0	3
Kestrel nest	1	0	0	0	0	0
Old owl bricks	6	6	0	2	7	0
Depredated owl nests	4	4	0	0	0	0

Table 2. Owl captures in Montana, Idaho, and Wyoming, May-June 1999.

Forest/Species	No. Nests	Avg. min. clutch size	No. individs. captured	No. banded	Adult males	Adult females	Juveniles
Beaverhead N.F.							
Boreal Owl	4	4.25	17	17	3	4	10
Saw Whet Owl	2	4.00	3	3	1	2	0
Payette N.F.							
Boreal Owl	6	3.25	17	17	1	3	13
Saw Whet Owl	4	5.25	20	19	0	2	18
Med. Bow N.F.							
Boreal Owl	1	2.00	1	1	0	1	0
Saw Whet Owl	0	-	0	0	0	0	0

Chapter 2: Boreal Owl Nest Box Use in the Blowdown on Routt National Forest

Marni Koopman and Dr. Gregory Hayward

Introduction

Natural disturbances such as the extensive blowdown in Routt National Forest in 1997 offer scientists rare opportunities to gain understanding of the consequences of large scale ecosystem alteration. Experimental studies at broad geographic scales can only be carried out in conjunction with natural disturbance. Thus, taking advantage of such rare occurrences by conducting ecological studies can provide insight otherwise impossible to gain, ultimately providing knowledge to improve forest management practices.

Boreal owls are dependent on high-elevation, mature forest for roosting, foraging and nesting. They inhabit subalpine forests throughout the Rocky Mountains where they are classified as a sensitive species. Subalpine ecosystems occur as discontinuous habitat in high elevation sites throughout the mountains of North America. Thus, individual subpopulations throughout the Rockies are disconnected, often with large expanses of unsuitable habitat between populations. According to metapopulation theory, persistence of such a population structure is highly dependent on dispersal. Dispersal acts to link small populations both genetically and demographically to form a sustainable unit.

Metapopulation theory suggests that individual populations are constantly in flux, with some decreasing (some even going extinct) while others are increasing (Wiens 1997). Over the long term, as habitat changes, new patches of suitable habitat emerge and previously suitable patches become uninhabitable. Such flux is difficult to observe due to the extensive amount of time over which such changes take place. A rare event like the Routt Divide blowdown, which removed a large patch of suitable habitat, may allow insight into the response of boreal owls to this change in habitat availability.

The use of nest boxes in assessing boreal owl reproduction and habitat preferences has been successful in the past. A 10 year study on the Payette National Forest involved monitoring over 400 nest boxes and was met with significant success (Hayward et al. 1992). However, because box use can be as low as 2% (or as high as 10%) occupancy, a great number of boxes must be hung in order to have sufficient sample size.

The goals of the proposed study are to determine how boreal owls adjust their nesting patterns to such large scale habitat alteration as the Routt Divide blowdown of 1997. We will

compare boreal owl nest box use and nesting success among the interior blowdown, blowdown/forest edge, and interior forest.

The blowdown may affect boreal owl nesting in a variety of ways. Because male boreal owls are highly philopatric, they may remain in or near their original range even if their productivity is reduced significantly. However, the blowdown may actually provide an abundance of prey and facilitate hunting, thus enticing boreal owls to nest along its edge or interior without reducing productivity. Finally, boreal owls may find the expansive open habitat uninhabitable and leave the area altogether.

Productivity of boreal owls can also be affected in a variety of ways. Males may remain philopatric, even when their habitat has been degraded. However, because females consistently choose new mates each year and find a new breeding territory, males who remain near the blowdown may have difficulty finding mates. We can evaluate this phenomenon by comparing call survey results carried out in the early spring to box occupancy results in early summer.

Productivity may also be reduced if only less experienced females mate with males in the blowdown area. Females in Scandinavia mated with older males each year, thus increasing their productivity with age (Korpimäki 1988). If inexperienced females mate with males in the blowdown, or if foraging success is reduced in the blowdown, clutch sizes are expected to be smaller and fledging success lower than in the interior forest or edge habitat.

Methods

We hung 289 nest boxes on Routt National Forest from July - October, 1998. Of these, 211 were hung on Hahn's Peak District and 78 on the Parks District. Sixty-one boxes were hung directly in the blowdown (on standing trees); 56 boxes were hung on blowdown/mature forest edge. The remaining 172 boxes were all hung in interior, mature spruce/fir, aspen, or lodgepole forest. All nest boxes were hung approximately 30 ft. high in a lodgepole, quaking aspen, Engelmann spruce, or subalpine fir. A pair of nest boxes was hung approximately every 0.3 miles along forest service road systems.

Rich Russell checked the nest boxes for evidence of use between 19 June - 30 June 1999. Box contents were recorded and the location of most boxes were verified with a GPS unit.

Results

No nesting owls were located in nest boxes on Routt National Forest during spring, 1999. We report Hahn's Peak and Parks districts both together and separately (Table 3). The number

of active squirrel, kestrel, and wasp nests were similar among mature forest, blowdown, and forest/blowdown edge (Table 4). However, the number of boxes containing evidence of mammal or bird use was 2-3 times higher in the mature forest than the blowdown and edge habitat types (Table 4).

Table 3. Nest box use on Routt National Forest, spring 1999.

Item	District		
	Parks (78 boxes)	Hahn's Peak (211 boxes)	Both (289 boxes)
Grass	12 (15.4%)	11 (5.2%)	23 (8.0%)
Lichen	2 (2.6%)	0 (0.0%)	2 (0.7%)
Pine Squirrel nest	0 (0.0%)	3 (1.4%)	3 (1.0%)
Kestrel nest	0 (0.0%)	1 (0.5%)	1 (0.3%)
Owl downy feathers	1 (1.3%)	3 (1.4%)	4 (1.4%)
Wasp nest	1 (1.3%)	8 (3.8%)	9 (2.9%)

Table 4. Occurrence of wasp nests, squirrel nests, kestrel nests, and evidence of owl visits in nest boxes on Routt National Forest, spring 1999. All use includes evidence of mammals or birds (lichen or grass nesting material, feathers, active nests) but excludes use by wasps.

Habitat type	wasp nests	squirrel nests	kestrel nests	owl feathers at entrance	All use
Mature forest (172 boxes)	6 (3.4%)	2 (1.2%)	1 (0.6%)	3 (1.7%)	26 (15.1%)
Blowdown (61 boxes)	1 (1.6%)	1 (1.6%)	0 (0.0%)	1 (1.6%)	3 (4.9%)
Edge (56 boxes)	2 (3.6%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	4 (7.1%)

Discussion

Boreal owl calling surveys were not conducted this winter by the Hahn's Peak District. Therefore, we cannot conclude whether box occupancy was related to owl abundance. Evidence from other locations further north in the Rocky Mountains (Beaverhead N.F., MT and Payette N.F., ID) indicates that boreal owl nesting activity was lower in spring, 1999 than the previous year (personal observation). However, nesting activity in Southwestern Colorado appeared to have increased relative to the previous year (C. Schultz, pers. comm.).

The absence of boreal owls nesting in boxes on the Routt National Forest in 1999 could be explained by a number of factors. Box use on the Medicine Bow National Forest was low (1 nest of 150 boxes) in 1999, suggesting that nesting activity in the region was low, possibly in

response to small mammal abundance. Low box use could also be a result of high availability of natural cavities. The abundance of mature aspen on Routt National Forest may provide plentiful nesting opportunities other than nest boxes. Some researchers maintain that nest boxes must age a year before becoming attractive to species searching for cavities of decayed wood. The presence of downy feathers on the entrances to many boxes indicates that owls did investigate the boxes for nesting, but chose not to inhabit them. Due to success in using nest boxes for monitoring boreal owl populations on many other forests, we are optimistic that we will have occupancy in the following years.

Chapter 3: Long-Term Monitoring of a Nest Box System on the Payette National Forest

Dr. Gregory D. Hayward

Introduction

A system of nest boxes on the McCall and New Meadows Districts was established in 1987 to examine the efficacy of employing nest boxes as a tool to monitor owl foraging habitat quality on managed forest lands. The system was expanded during the first 3 years of the monitoring program to a maximum of 455 boxes. Although the nest box program was established to test a monitoring approach, it has yielded additional benefits for natural resource managers and research. Furthermore, the program has joined several government and private organizations in a cooperative program to meet a diversity of goals.

In 1999, field work was supported largely by the Idaho Fish and Game. Other agencies contributing funding or logistical support included University of Wyoming, Payette National Forest, and Bureau of Land Management. Information collected during the summer of 1999 supported the following major efforts (as demonstrated from past publications from our lab, these studies contribute in lesser ways to many projects):

- 1) Long-term monitoring of boreal and saw-whet owl nest occupancy and productivity for the Payette National Forest. This is the only long-term monitoring program of its kind in North America.
- 2) Research examining the relationship between northern flying squirrels and fungi/lichen. This research has important implications for understanding flying squirrel ecology and determining the critical link between these squirrels and mycorrhizal fungi (fungi important to tree establishment and productivity).

- 3) Research funded by the University of Wyoming examining the habitat associations of boreal owls at landscape scales. This study will use 7 years of monitoring, prior to the Blackwell fires, to examine habitat features associated with boreal owl site occupancy and productivity.
- 4) As described earlier in this report, tissue samples from boreal owls on the Payette will be important in studies examining movements of boreal owls among subpopulations in North America, particularly the Rocky Mountains. Data from the Payette National Forest will play a critical role in this study.

Methods

Our long-term monitoring program has continued without interruption for 12 years. Rationale for the work and methods have been included in earlier reports. Therefore we will provide only an abbreviated explanation of methods here.

Nest Box Placement

We hung 283 boxes on the McCall and New Meadows districts of the Payette N.F. in July 1987 and an additional 172 boxes were hung by August 1989. Due to damage to individual boxes, changes in access, and removal of trees by wood-cutters or loggers the number of boxes available for wildlife use varies each year. Over the first 6 years of monitoring, landscape characteristics did not change significantly. During this period, however, spruce beetle attacks began to kill many overstory trees in portions of the monitoring area but stem density and many characteristics of forest structure did not change significantly. In 1993, after the owl nesting season, timber harvest was initiated in a portion of the study area south and west of Sesash summit. After the owl nesting season in 1994 a portion of the monitoring area experienced a major stand removal, wildfire. This disturbance changed habitat characteristics over broad landscapes. The characteristics of the 1994 fire and the timber sales begun in 1993 are documented in agency records. Eighty nest boxes were initially destroyed or rendered unusable by the 1994 fires. Management activities associated with the fire have lead to continual loss of nest boxes from the monitoring system. We continued replacing nest boxes each year since the fire as treefall, harvest, and other disturbances make boxes unusable. We attempt to relocate nest boxes near their original site when possible. In some instances, however, safe trees for box attachment are not available and boxes have been placed along new monitoring routes or within past routes.

When we established the nest box system we spaced nest boxes at 0.5 km intervals along primary, secondary, and primitive haul roads. Wherever possible, we hung the boxes along several roads in a network so the boxes formed a grid-like pattern rather than a single string of

boxes along 1 corridor. In many areas, the existing road network and road management policy lead to linear configurations; approximately 30% of the boxes were in a grid-like pattern.

Each box was hung in a tree 10 to 70 m from the road in a position making the box difficult to see from the road. We climbed live conifers using forester's climbing spurs and hung each box between 4.5-10 m high after trimming all branches below box height. In all cases the box faced a small (at least 3x3 m) forest opening providing a clear flight path to the box.

Nest Box Design And Construction

Box design followed Korpimäki (1985). Inside box dimensions were: bottom 20x20 cm, front height 46 cm, back height 51 cm, and cavity dia 9 cm. We constructed nest boxes from rough cut, 3 cm pine and fir. Constructing 300 boxes required 382 m of 3x20 cm (1x8 in) and 382 m of 3x25 cm (1x10 in) lumber. Five cm of wood chips and saw-dust were placed in the bottom of each box.

Monitoring Nest Boxes

We monitored nest boxes on the Payette N. F. for 12 years (1988-1999). We checked boxes each spring when snow conditions permitted travel. Monitoring generally began between 22 and 30 May (but as late as 8 June) and extended into early July. However, virtually all boxes were initially checked by the end of June. To determine nest box use, we climbed each tree once each spring during the nesting season using climbing spurs or examined the nest box using a nest-box checker (Hayward and Deal 1993) and recorded nest box contents. Adult female owls and owlets in the box were captured, identified, and banded, and the box was recorded as occupied. We attempted to capture male owls at occupied boxes using a box trap. Males are captured when they bring prey to the nest at night. This method is successful at only a fraction of the nest boxes. Presence of a mat of owl feces and prey remains or pellets was considered evidence of a nesting attempt. Owl species was not recorded unless diagnostic feathers were found in the box or the species could be identified by night-time vocalizations heard in the vicinity of the box. We removed nest contents other than wood chips and sawdust and repaired damaged boxes.

Monitoring Results

Between 8 June and 30 June, 1999, Tim Hampton, Tom Doser, Marni Koopman, and Jason Bennett checked an estimated 344 usable nest boxes. Overall, we observed animals in 17 (4.9%) of the nest boxes and sign of use in at least 77 (22.4%) more of the boxes. As in other years, boxes were used by northern flying squirrels (*Glaucomys sabrinus*), pine squirrels (*Tamiasciurus*

hudsonicus), saw-whet owls (*A. acadicus*), boreal owls (*Aegolius funereus*), American kestrels (*Falco sparverius*), and northern flickers (*Colaptes auratus*).

Boreal owls nested in 6 (1.7%) of the nest boxes. Northern saw-whet owls nested in 4 (1.2%) of the nest boxes (Table 4). Combining boxes used by boreal and saw-whet owls and those with sign that nests were at least initiated in them this year (eggs, fresh partial brick), 14 (4.1%) of the usable nest boxes were used by owls (Table 4). Use by owls, especially boreal owls was slightly lower than the previous year.

We captured and banded 3 adult female, 1 adult male, and 13 nestling boreal owls. We captured and banded 2 adult female, 0 adult male, and 18 nestling saw-whet owls (Table 2).

We observed flying squirrels in 6 (1.7%) of the boxes, the first increase since 1989 (Table 4). Lichen or other sign of flying squirrels occurred in 55 other boxes. The number of boxes with lichen is greater than in 1997 and 1998, but still far less than in 1996 (86 boxes) and earlier years. This sign (lichen) is difficult to interpret by year of origin and we don't feel this metric alone should be used to interpret changes in flying squirrel abundance. However, the magnitude of the difference among years, and the coincident pattern for lichen and flying squirrel nests, suggests a potential difference in the number of flying squirrels using the nest boxes.

Table 4. Nest box occupancy by boreal owls, saw-whet owls, and flying squirrels from 1988-1999 on the Payette National Forest, Idaho. Percent use given in parenthesis refers to proportional use of the boxes classified as usable that year. These results should be considered preliminary as the criteria for 'usable' boxes could be approached differently and further analysis of habitat use patterns may suggest a reasonable system for stratifying boxes. Boxes recorded as unknown owls includes boxes with cached prey, evidence of the start of a nest, or frequently, evidence of predation during nesting.

Year	Boreal owl	Saw-whet owl	Unknown owls	Flying squirrels	Usable boxes
1988	9 (3.3)	5 (1.9)	3 (1.1)	9 (3.4)	267
1989	11 (3.7)	6 (2.0)	3 (1.0)	18 (6.0)	298
1990	22 (5.3)	13 (3.1)	5 (1.2)	24 (5.7)	417
1991	15 (3.5)	11 (2.6)	11 (2.6)	22 (5.2)	426
1992	15 (3.4)	12 (2.7)	7 (1.6)	18 (4.1)	441
1993	13 (2.9)	11 (2.5)	8 (1.8)	10 (2.3)	444
1994	14 (3.2)	2 (0.5)	6 (1.4)	15 (3.4)	440
1995	12 (3.4)	5 (1.4)	1 (0.3)	13 (3.7)	355
1996	5 (1.3)	4 (1.0)	4 (1.0)	7 (1.8)	382
1997	1 (0.2)	7 (1.7)	2 (0.4)	6 (1.4)	411
1998	7 (1.8)	9 (2.3)	9 (2.3)	4 (1.0)	393
1999	6 (1.7)	4 (1.2)	4 (1.2)	6 (1.7)	344

No pine squirrels were observed nest boxes, but grass nests (which we interpret as sign of pine squirrel use) occurred in 32 boxes. In 1997, we recorded no pine squirrels in boxes and only 12 boxes with grass nests. As with lichen, however, grass in nest boxes is difficult to interpret by year of origin.

Discussion

Reports from 1996-97 included complete discussions of the patterns in owl and flying squirrel occupancy observed during the past decade. Therefore, this discussion will be brief.

Boreal and saw-whet owls both showed decreased rates of nest box occupancy. The pattern of occupancy for boreal owls suggests a delayed negative response (1996, 1997) to the 1994 fires (boreal owls occupied similar numbers of boxes from 1991-1995) and potentially a partial recovery initiated in 1998 and retained through 1999. The 1994 fire may have eliminated nearly 50% of the forest in the area monitored by the nest box system (Richard Russell is currently examining GIS coverage for the area). Given this loss, I predict that boreal owl nest box occupancy will remain at or below 2% in the future.

The nest box system was established primarily to examine boreal owl population trend. Habitat use and trend in saw-whet owls has not been closely examined. I hope to begin to examine the data on saw-whet owl use in the near future. The pattern of occupancy for saw-whet owls is not easily explained by the pattern of habitat disturbance in the monitoring area. Saw-whet owls reached their lowest level of occupancy prior to the fire (in the spring prior to the fire). Occupancy in 1998 was similar to the high level of occupancy observed from 1990-1993, but was subsequently lower in 1999.

Nest box use by flying squirrels, as measured by the number of nest boxes occupied by squirrels during monitoring and by the number of boxes with lichen, increased slightly between 1998 and 1999. Like boreal owls, occupancy rates for flying squirrels did not decline immediately following the 1994 fire but began declining after one year. Unlike boreal owls, flying squirrel occupancy did not recover in 1998 but continued to decline. Interpreting the occupancy rates is difficult. While we find flying squirrels in nest boxes each year, we have little understanding regarding the use of 'occupancy' by flying squirrels as a measure of population characteristics. Unlike the boreal and saw-whet owls, flying squirrels do not consistently occupy a single cavity or nest box through the breeding season. Furthermore, flying squirrels who are not breeding, use boxes for roosting. Finally, because flying squirrels may quietly leave a nest box while we climb the tree to check for occupancy, some squirrels occupying nest boxes may not be detected during monitoring. We suspect, however, that bias in

the measurement of occupancy can not be responsible for the perceived decline. During the period of declining occupancy rates (1996-1998) a graduate student (Shelli Dubay) whose dissertation focuses on flying squirrels, has been assisting with field work. Therefore, we would expect the probability of detecting flying squirrels would be highest during this period because of the efforts to note all flying squirrels.

I would like to close with a note regarding the future of our monitoring program. The increase in boreal owl occupancy observed in 1998 was unexpected! We were happy to see the population remain stable between 1998 and 1999. However, the long-term consequences of the 1994 fire on boreal owls can not be predicted without additional monitoring. Furthermore, because of the importance of the Payette N.F. in our work on movements by boreal owls, we expect to continue monitoring the nest box system for the next two years. We will be seeking funding to support the monitoring program from a number of sources. Currently we have proposals submitted to NSF and the EPA. We will be seeking funding from several other government and private sources.

Richard Russell is scheduled to complete his Master's thesis by early this spring. This work will include an analysis of trend in boreal owls based on occupancy and productivity. The major focus of the work will be an analysis of landscape scale habitat characteristics associated with boreal owls. This work will use the long-term monitoring data on occupancy and productivity, and GIS analysis of vegetation and other habitat features. The products from this work will be written to provide managers with information to more effectively evaluate the potential effects of land management decisions.

Acknowledgments

We greatly appreciate the efforts of Jason Bennett, Melissa Miller, and Jason Helvey in building and hanging nest boxes on the Routt National Forest last fall. We also appreciate the help of Phil Hayward, Tony DeSilva, and Tom Bills for building and hanging boxes on the Bridger-Teton National Forest. We also thank Rich Russell, Tim Hampton, Tom Doser, and Jason Bennett for checking boxes in record time. We are indebted to Jane Ingebretson, Joe Harper, Jenny Newton, Floyd Gordon, Chris Hescocock, Benton Smith, Kit Buell, John Ormiston, Sandy Jacobson, Larry Michelson, Tom Komberic, and Robert Skorkowski for assistance, patience, and vehicle and housing provision. Finally, we thank the Routt, Bridger-Teton, Caribou, Beaverhead, Bitterroot, Flathead, Idaho Panhandle, and Payette National Forests for providing housing and logistical support. We also thank Chris Schultz, Tom Holland, and Ted Swem for providing us blood samples from Colorado and Alaska.

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